Study of the relation among Resist components, Outgassing species and Contamination

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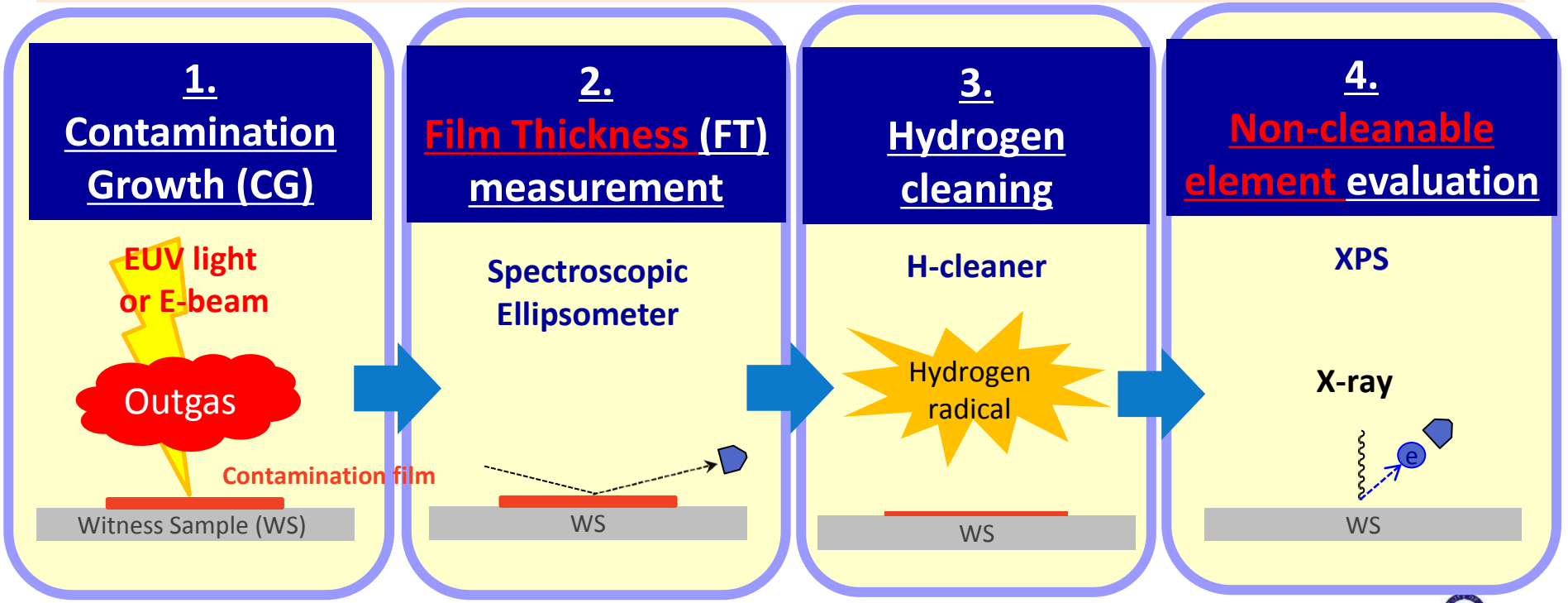
Outline

- **Introduction and objective of this work**
- **Experiments and results**
  1. Identify the main contributors of outgassing components to carbon contamination.
  2. Investigate the species of outgassing by Residual Gas Analyzer (RGA).
  3. Compare EUV and E-beam.
- **Summary**

Introduction : Outgassing test requirement

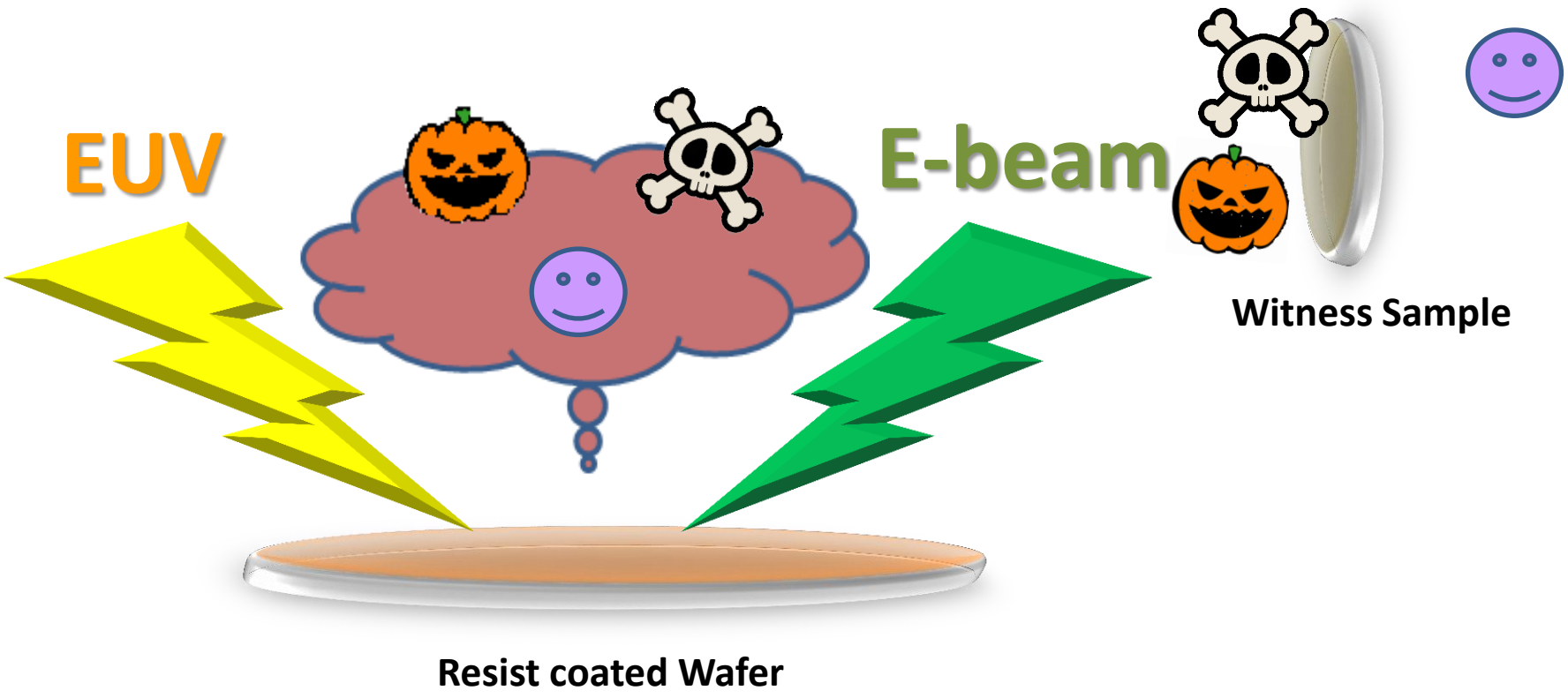
- EUV resists must be passed the outgassing tests before being exposed in the EUV HVM scanner.
- Outgassing test source of either EUV light or E-beam are used to expose Resists and/or Witness samples (WS).
- OK judgment is given when the contamination film thickness and atomic% of non-cleanable element fall the certain critical values.



Objective :

1. What species is the contributor of contamination?

2. Are the EUV and E-beam comparable?



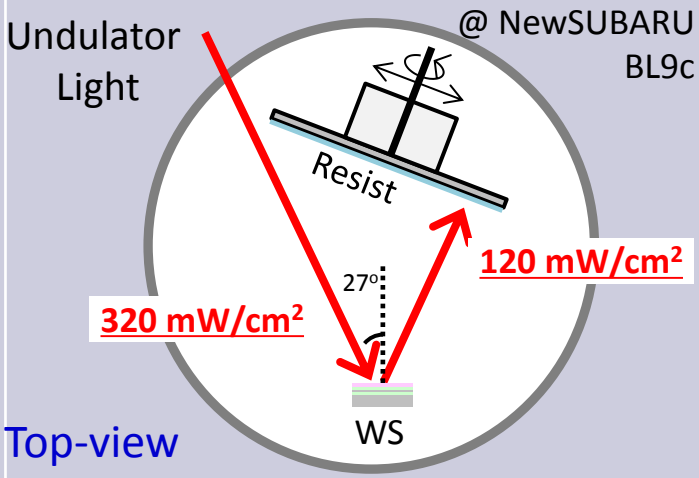
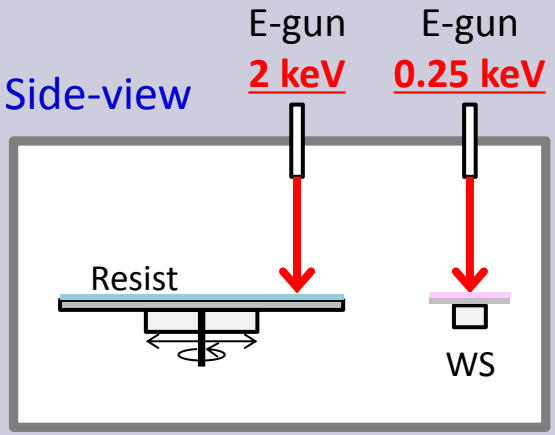
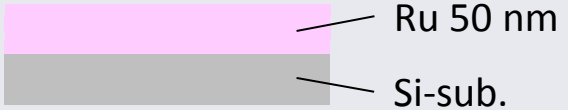
Experiments

1. Get the breakdown of resist components in total contamination thickness by using the special sample set.
Each sample composed of the combination
w/ or w/o of PAG and Protecting Unit (PU).

2. Identify the species of outgassing and carbon contamination by RGA.

3. Compare those results between EUV and E-beam exposure.

Outgas evaluation tool @ EIDEC

	High Power EUV - HERC* analysis tool -	Electron Beam (EB) - EUVOM-9000 -
Tool geometry		
Vacuum conditions	Base: 3~4x10-6 Pa Exposure: 1~2x10-5 Pa	Base: 3~4x10-7 Pa Exposure: 2~4x10-6 Pa
Resist thickness	60nm	
Witness Sample (WS)		

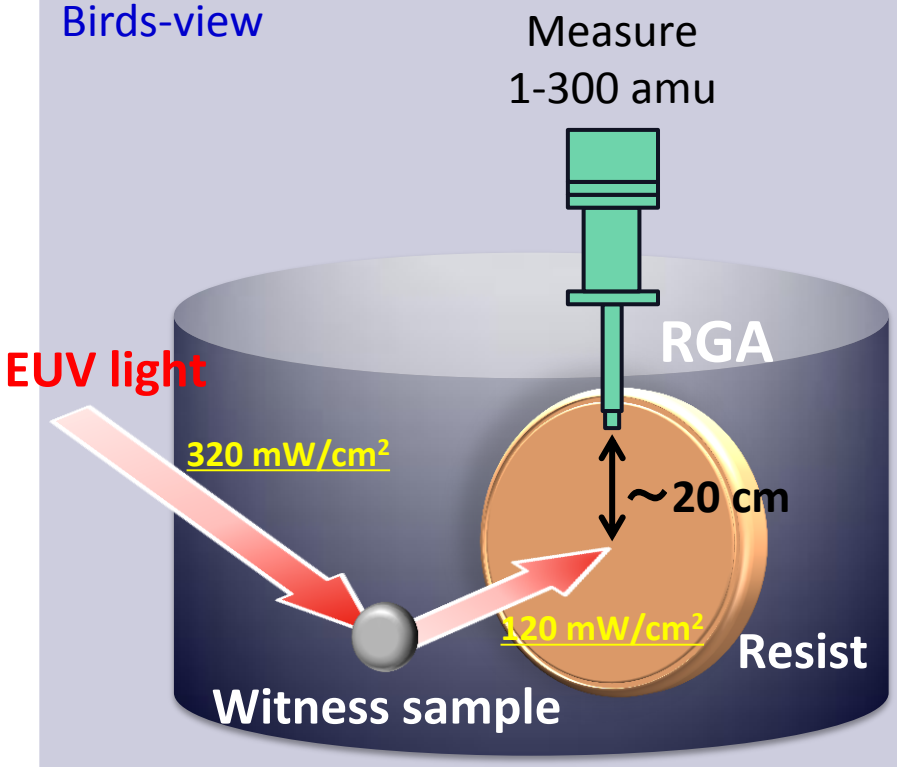
* HERC: **H**igh power **E**UV **R**esist **C**ontamination

RGA measurement configuration

High Power EUV

HERC* analysis tool
@ NewSUBARU BL9c

Birds-view

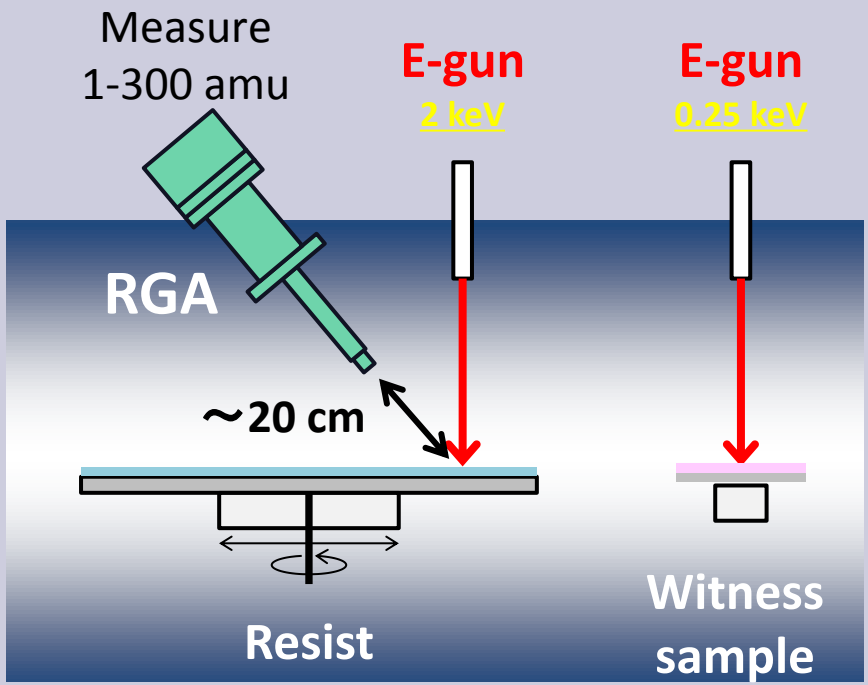


Expose 2 wafers (200mmϕ)
with 2.5xE_0 and calibrate for a
300mmϕ wafer

Electron Beam (E-beam)

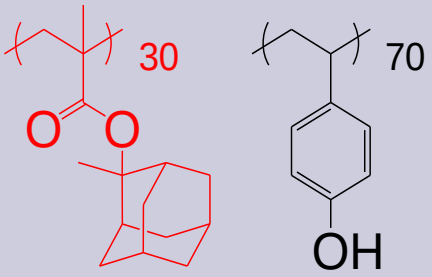
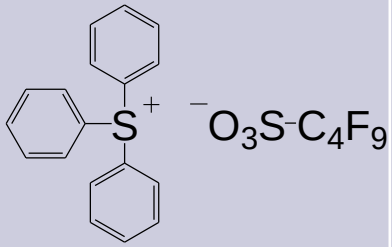
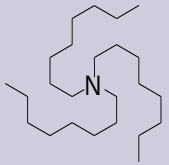
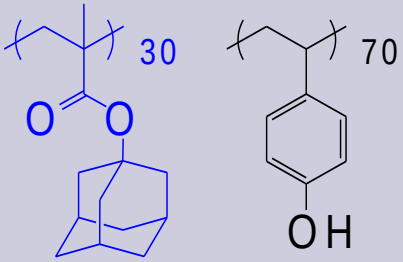
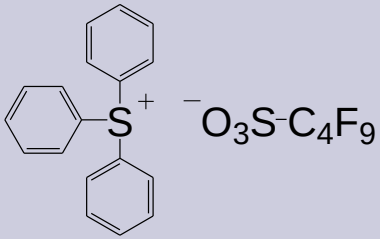
EUVOM-9000
@ EIDEC

Side-view

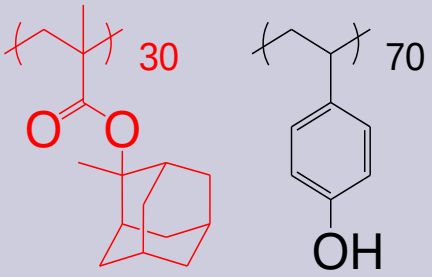
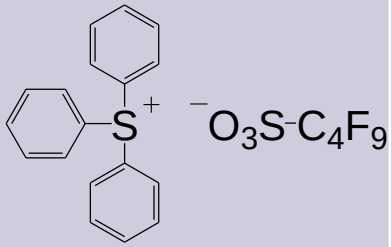
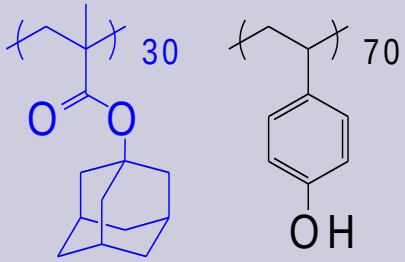
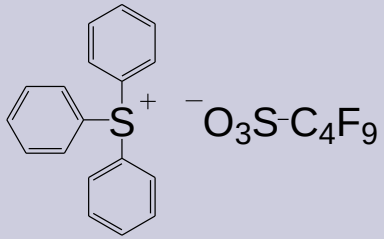


Expose 1 wafer (300mmϕ)
with E_0 (60 min x1)

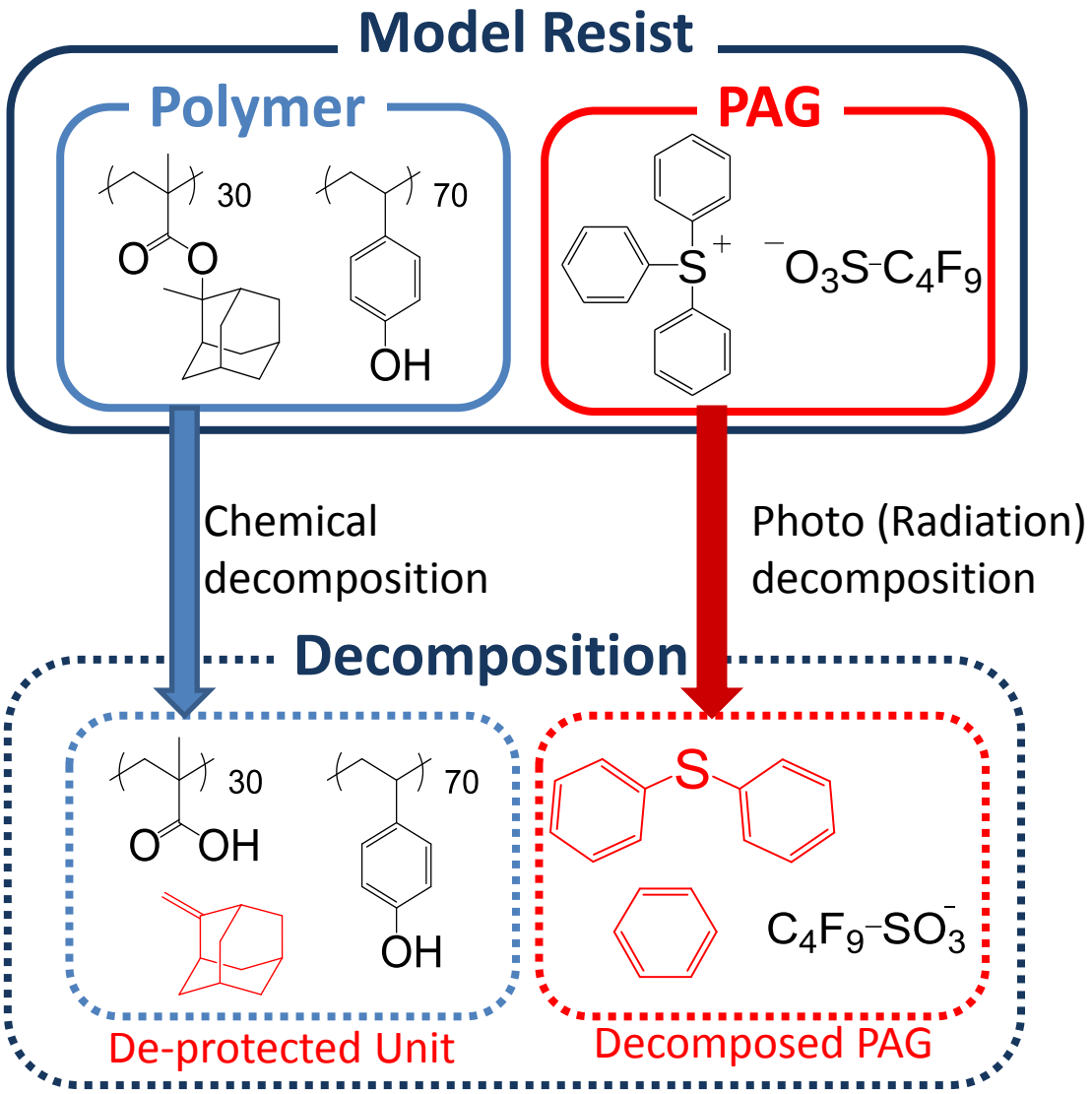
Sample Set composition

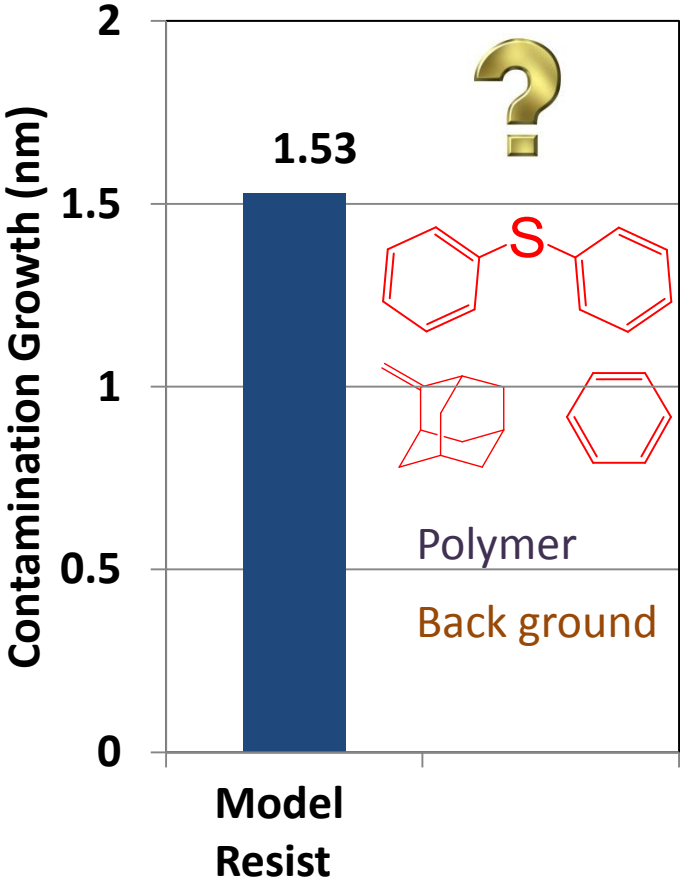
Sample Concept	Polymer	PAG (20wt% of polymer)	Quencher (0.1mol of PAG)
Model Resist	 Acid labile unit		 Tri-n-octylamine
PAG free		**none**	
PU free	 Acid stable unit		
PAG and PU free		**none**	

Outgassing source of each sample

Sample Concept	Polymer	PAG (20wt% of polymer)	Possible Source of Contamination
Model Resist	 Acid labile unit		▪ Polymer ▪ Protecting Unit ▪ PAG ▪ Background
PAG Free		none	▪ Polymer ▪ Directly decomposed Protecting Unit ▪ Background
PU Free	 Acid stable unit		▪ Polymer ▪ PAG ▪ Background
PAG and PU Free		none	▪ Polymer ▪ Background

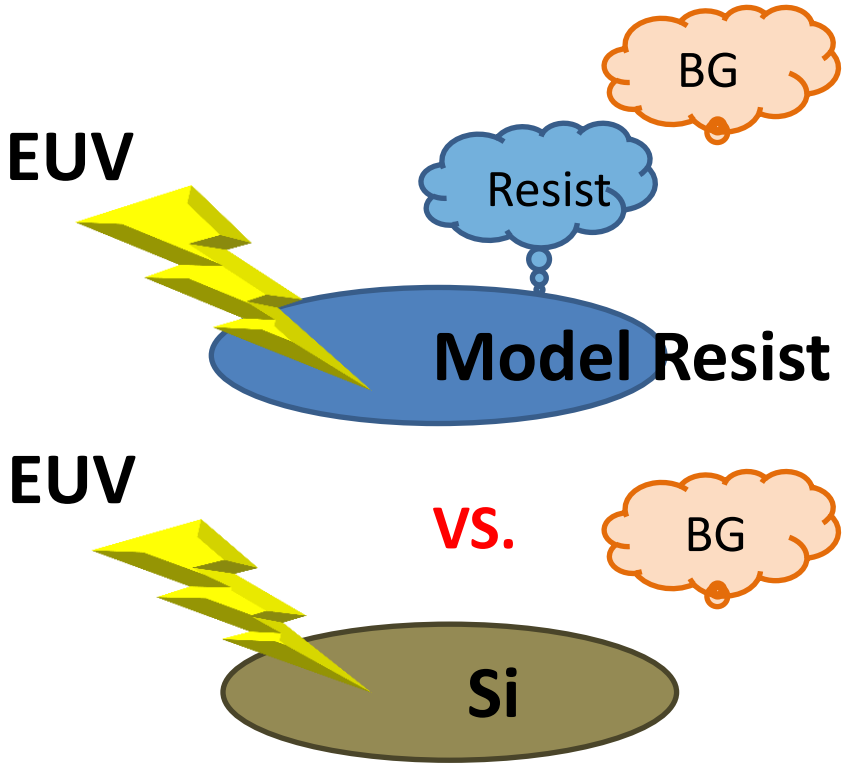
Model Resist Outgassing mechanism and measured contamination

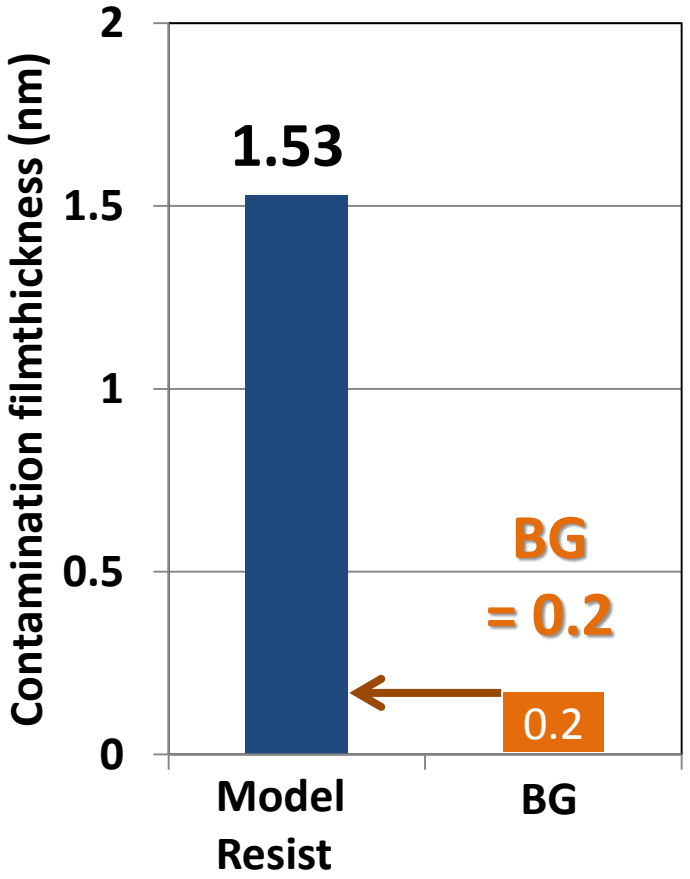




- How much is the contribution of each outgassing species?

Contribution of Background (BG) Atmosphere in Contamination Thickness

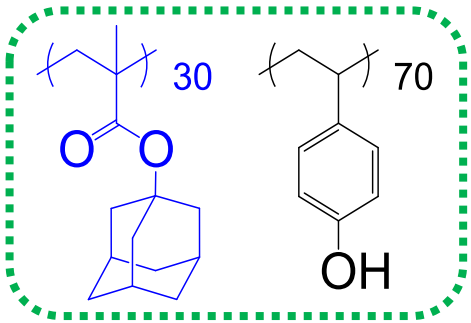




■ Contribution of Background in Contamination Thickness is 0.2 nm.

Contribution of base polymer

PAG and PU free composition



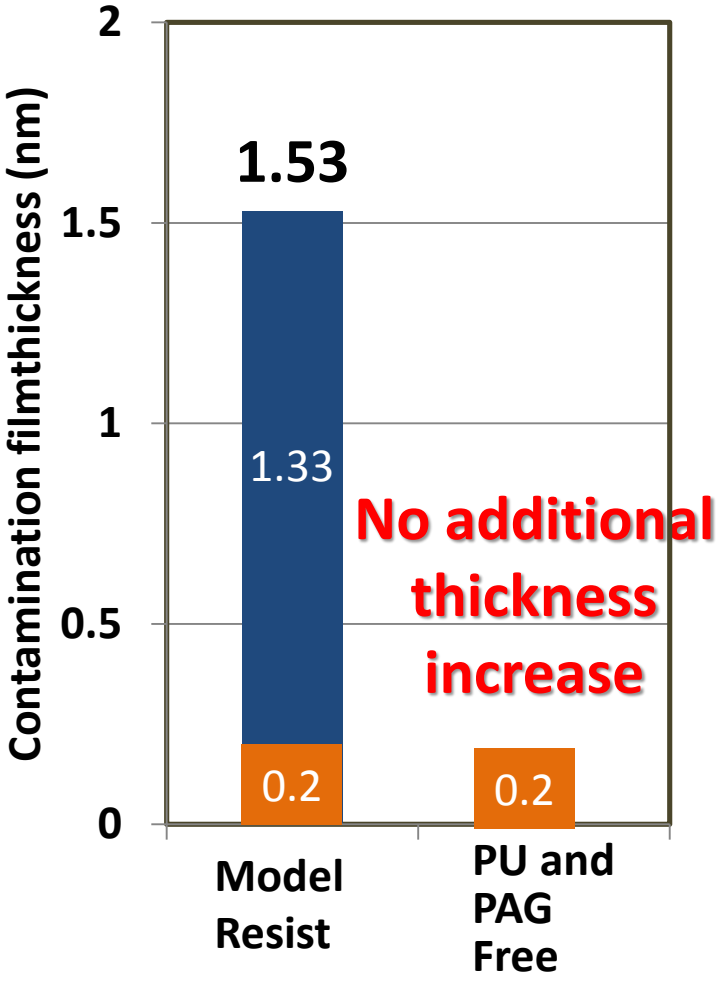
Acid stable unit

no PAG

Polymer

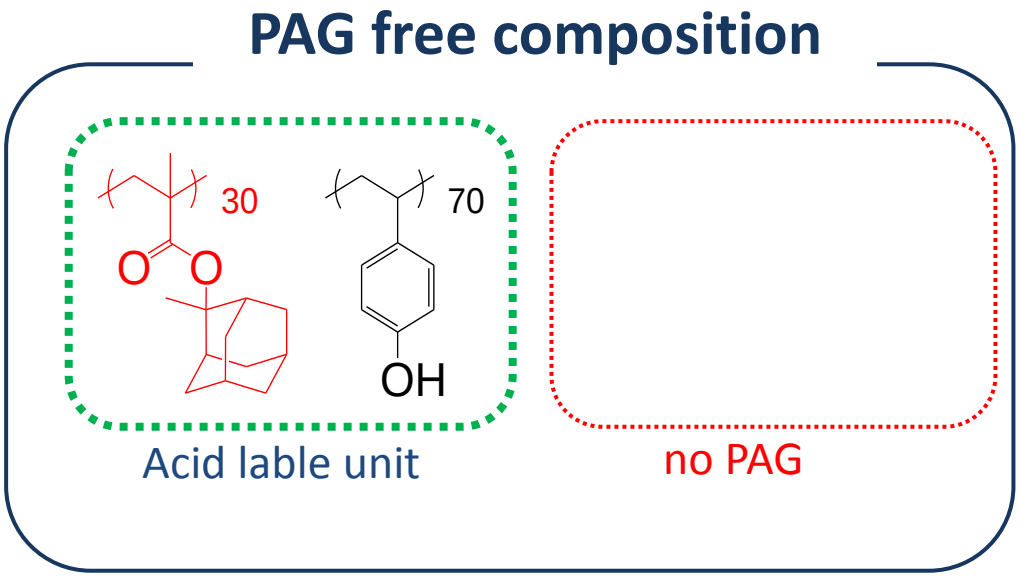
~~**Protecting Unit**~~

~~**PAG**~~



- Negligible contribution from polymer.

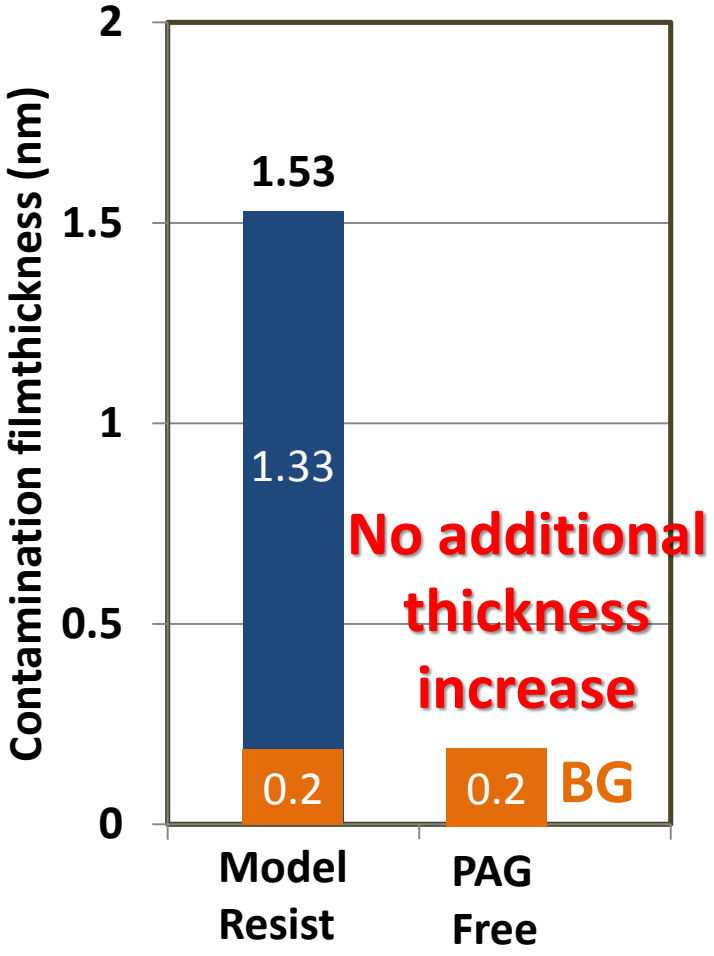
Contribution of PU direct decomposition w/o PAG



Polymer

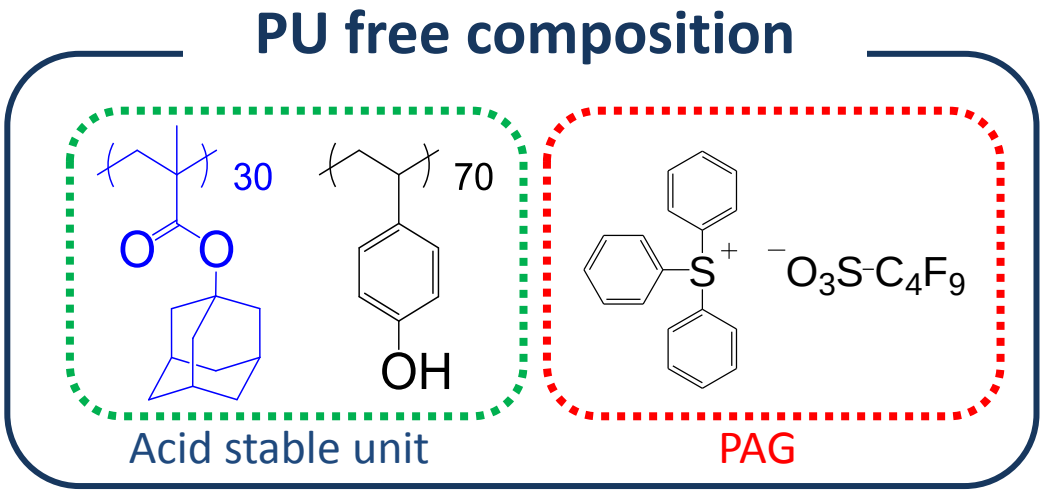
Protecting Unit

~~**PAG**~~



- Negligible contribution from PU direct decomposition.

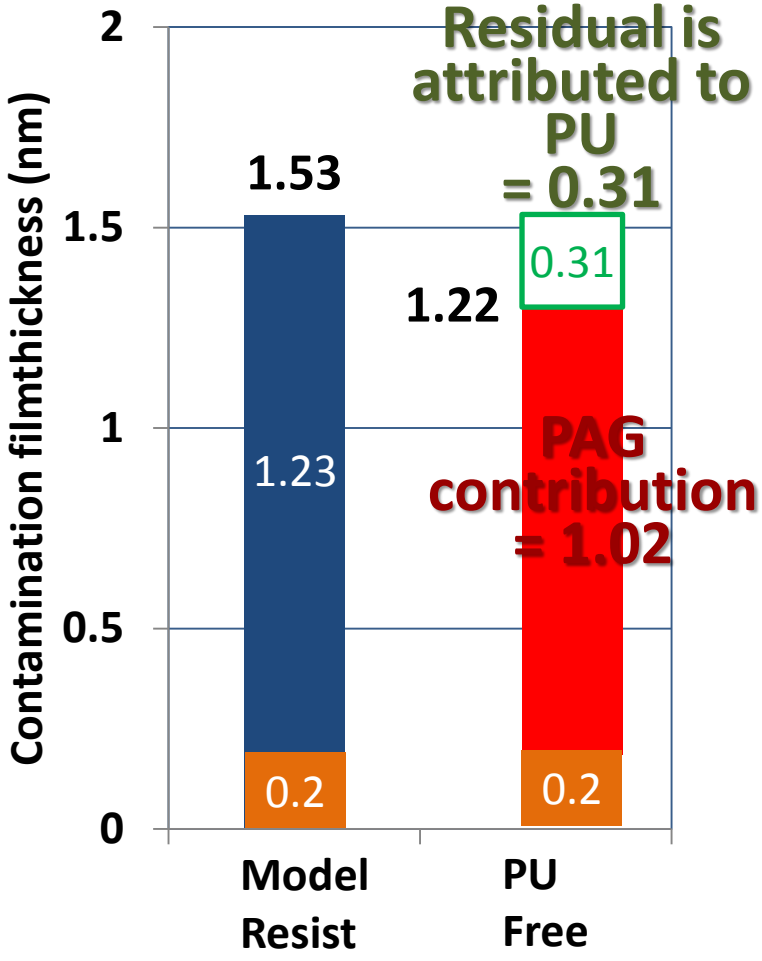
Contribution of PAG and PU



Polymer

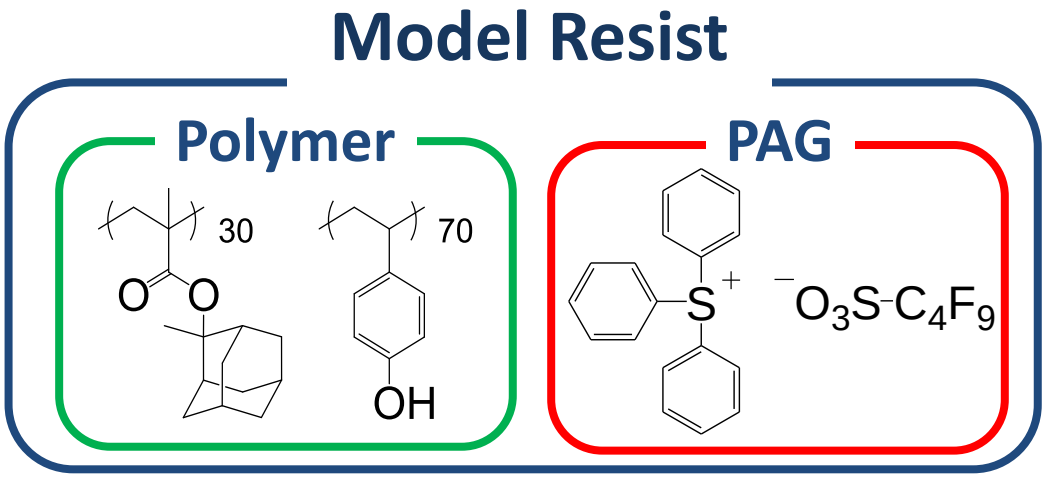
~~**Protecting Unit**~~

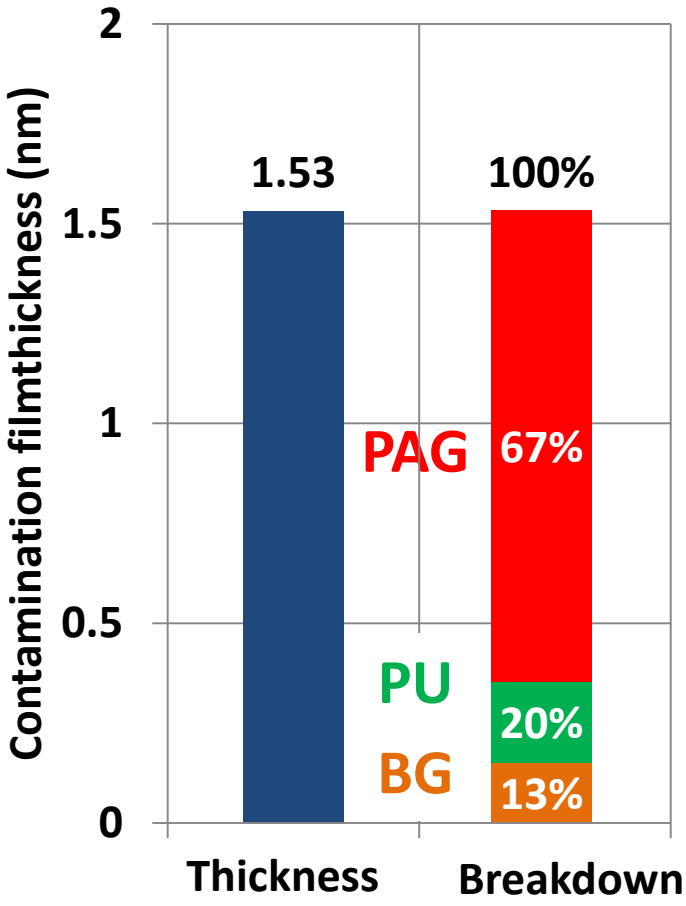
PAG



- Contribution of PAG : 1.22 – 0.20 = 1.02 nm
- Contribution of PU : 1.53 – 1.22 = 0.31 nm

Summary 1 : Contamination Thickness composition by EUV

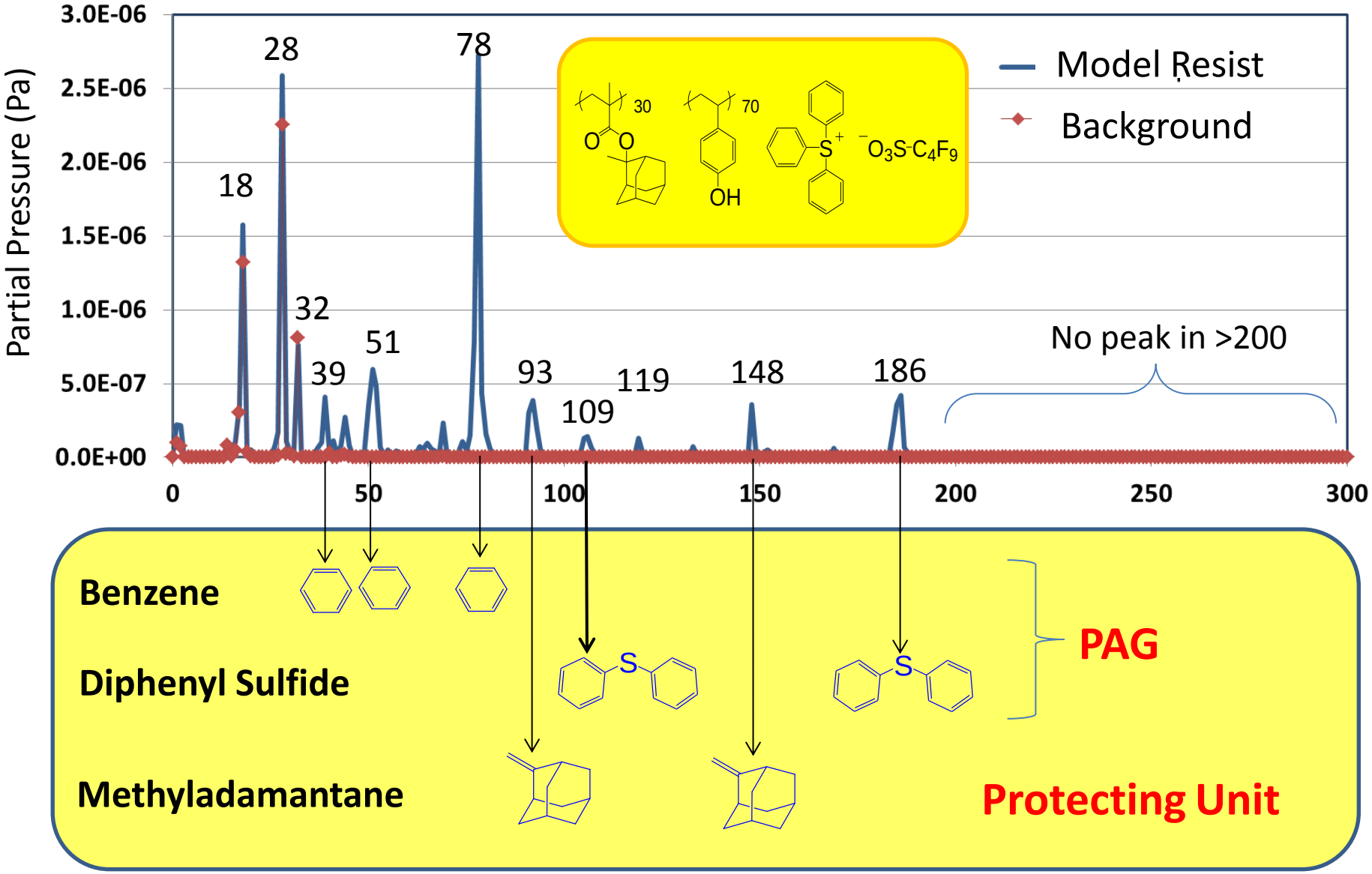




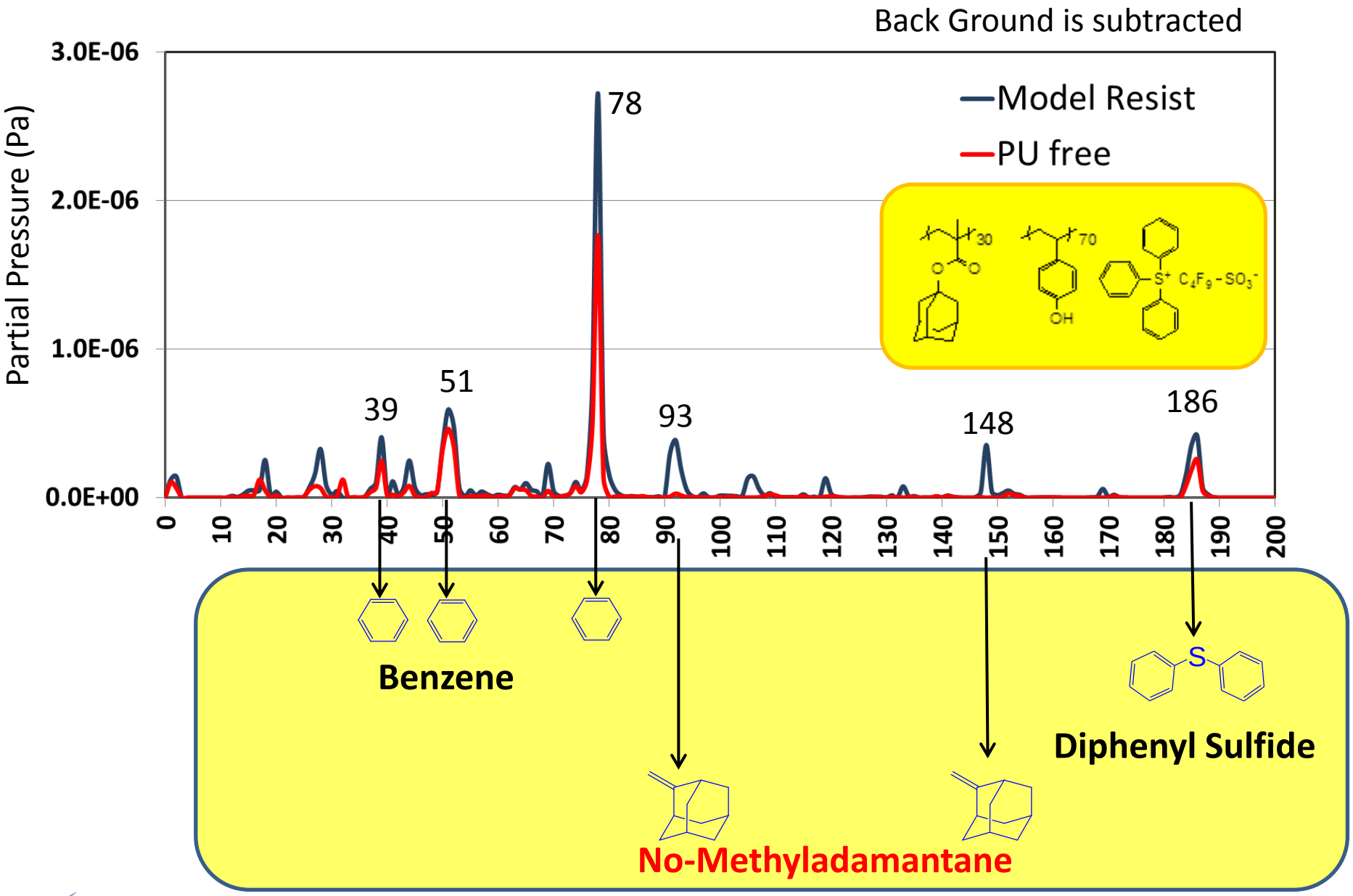
- ～70% of the Contamination Thickness is by PAG component

What species are found in RGA ?

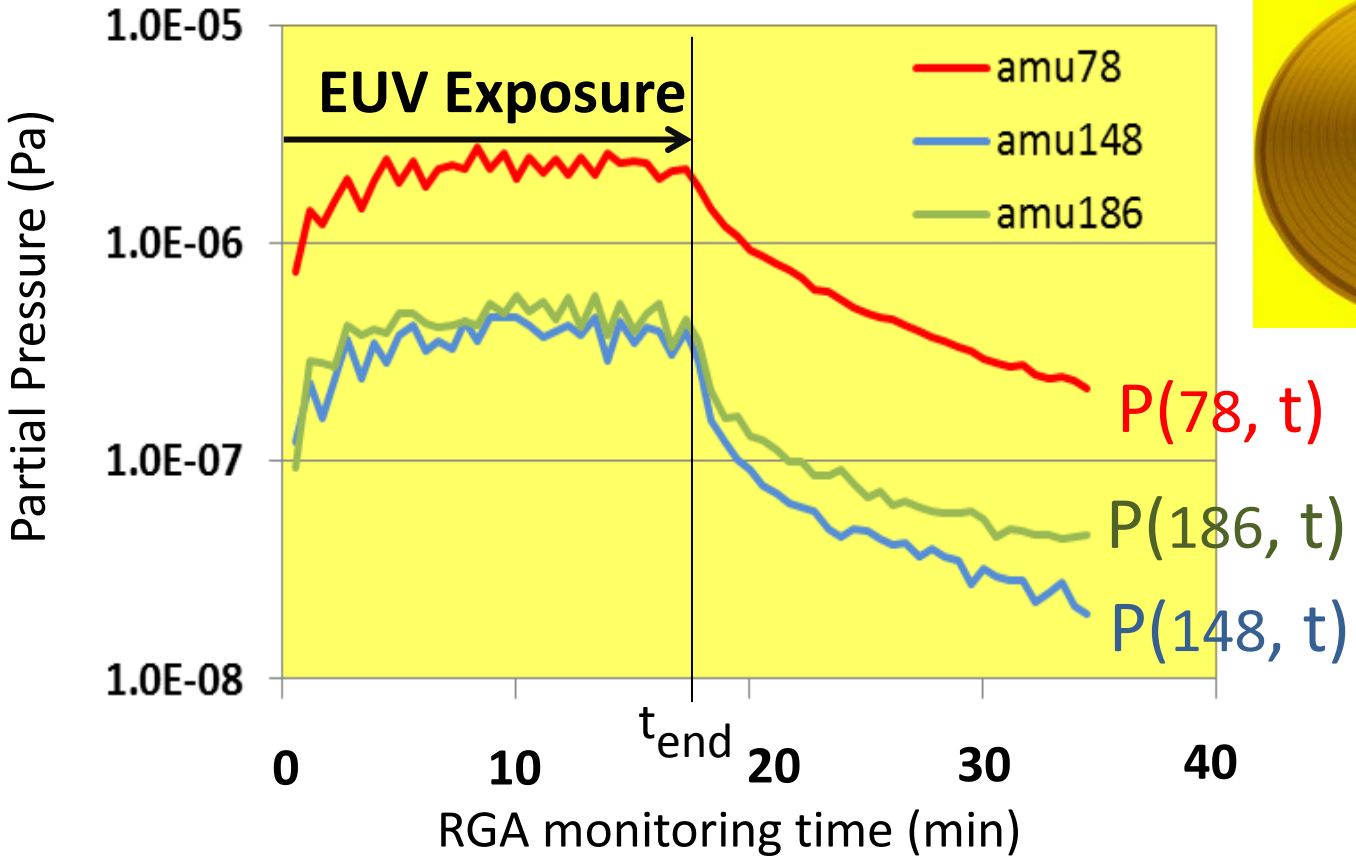
RGA Spectrum of Model Resist

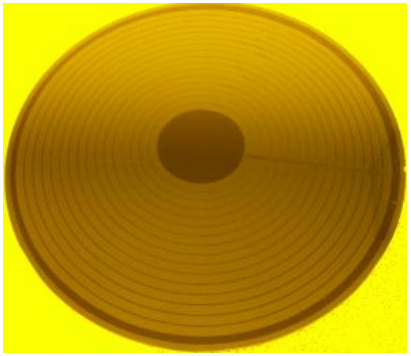


RGA Spectrum of PU free sample (Contribution of PAG)



Total outgassing calculation

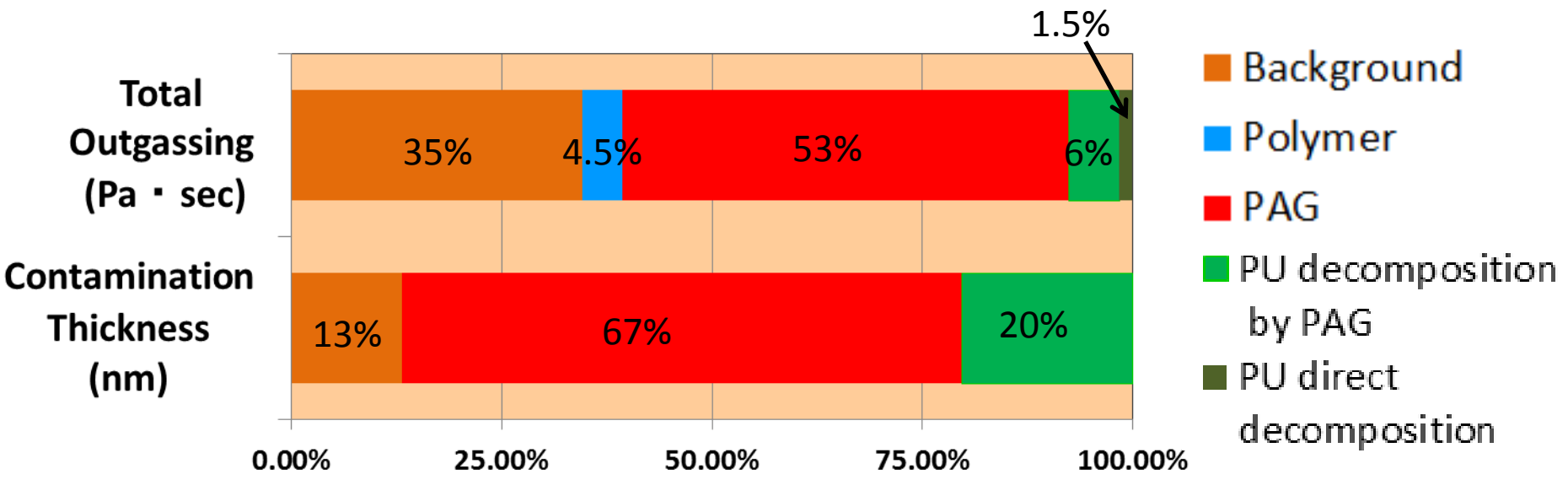




Partial Pressure change during the exposure of a 200 mm wafer with the Model Resist by EUV

Total Outgassing : $$P_{sample}(total) = \sum_{t=0}^{t_{end}} \sum_{amu=1}^{300} P(amu, t) \times$$ factor for a 300mm wafer

Summary2: Composition of Outgassing and Contamination thickness by EUV exposure



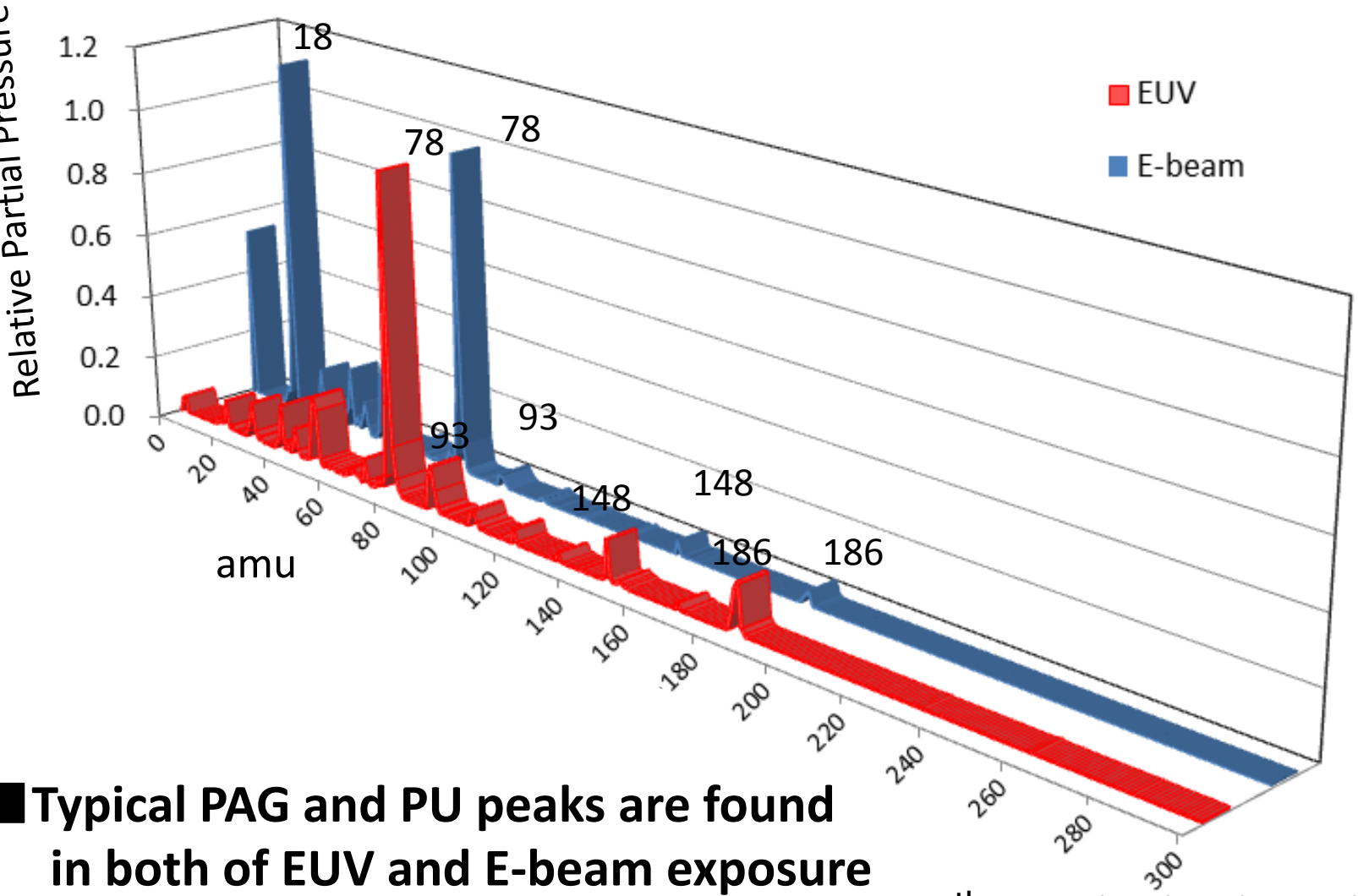
■Gas volume of PAG is **about half in total amount** but contribution in the **contamination is about 70%**.

■Polymer is also outgassing but does not make contribution to the contamination

■Outgassing from the **PU direct decomposition** is detected. But it is **very small**, and not be seen in contamination thickness.

Comparison between EUV and E-beam

RGA signals of Model Resist by EUV and E-beam

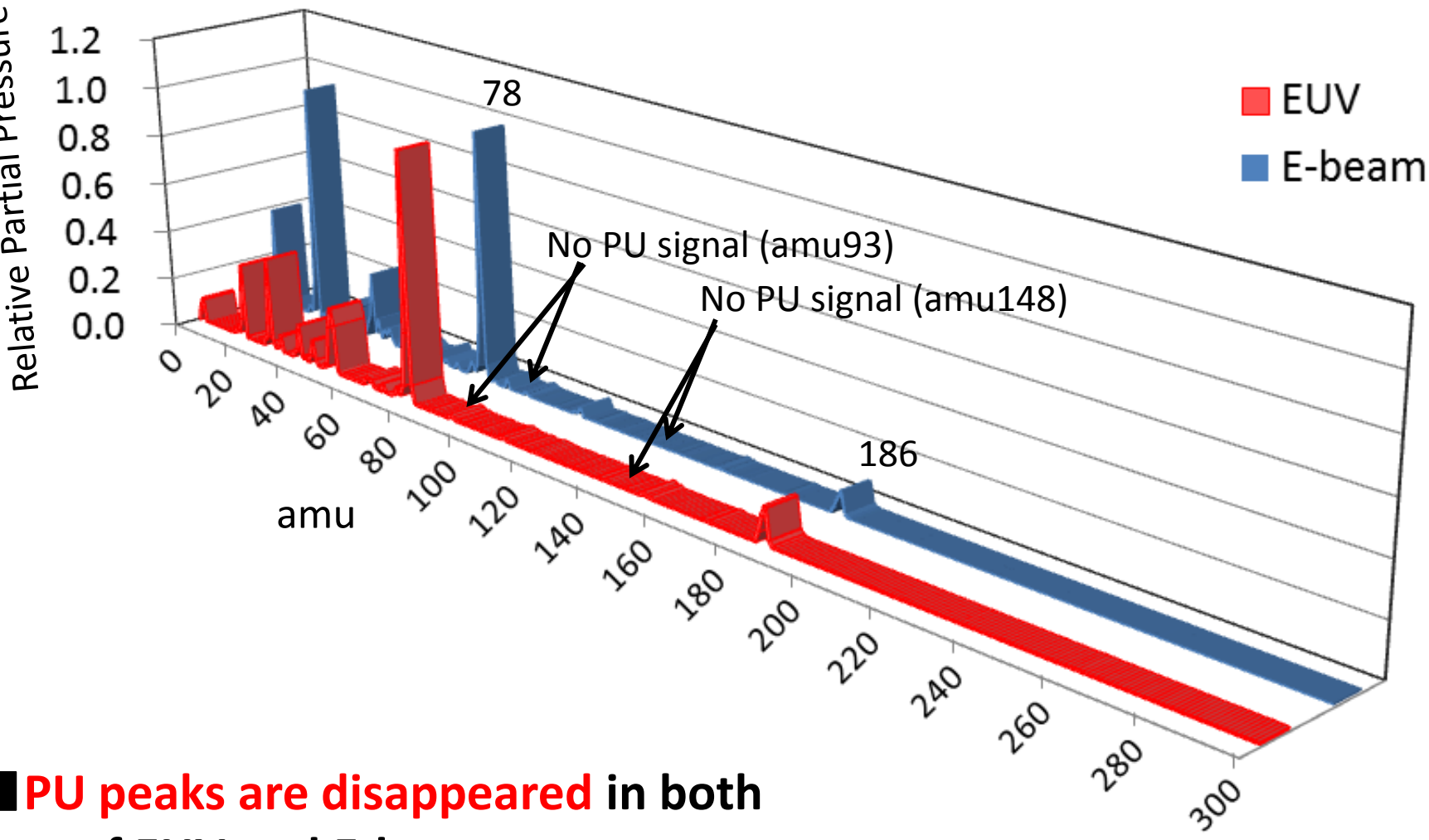


■ **Typical PAG and PU peaks are found in both of EUV and E-beam exposure**

Normalized at the peak of amu78

BG are subtracted

RGA signals of PU free sample by EUV and E-beam

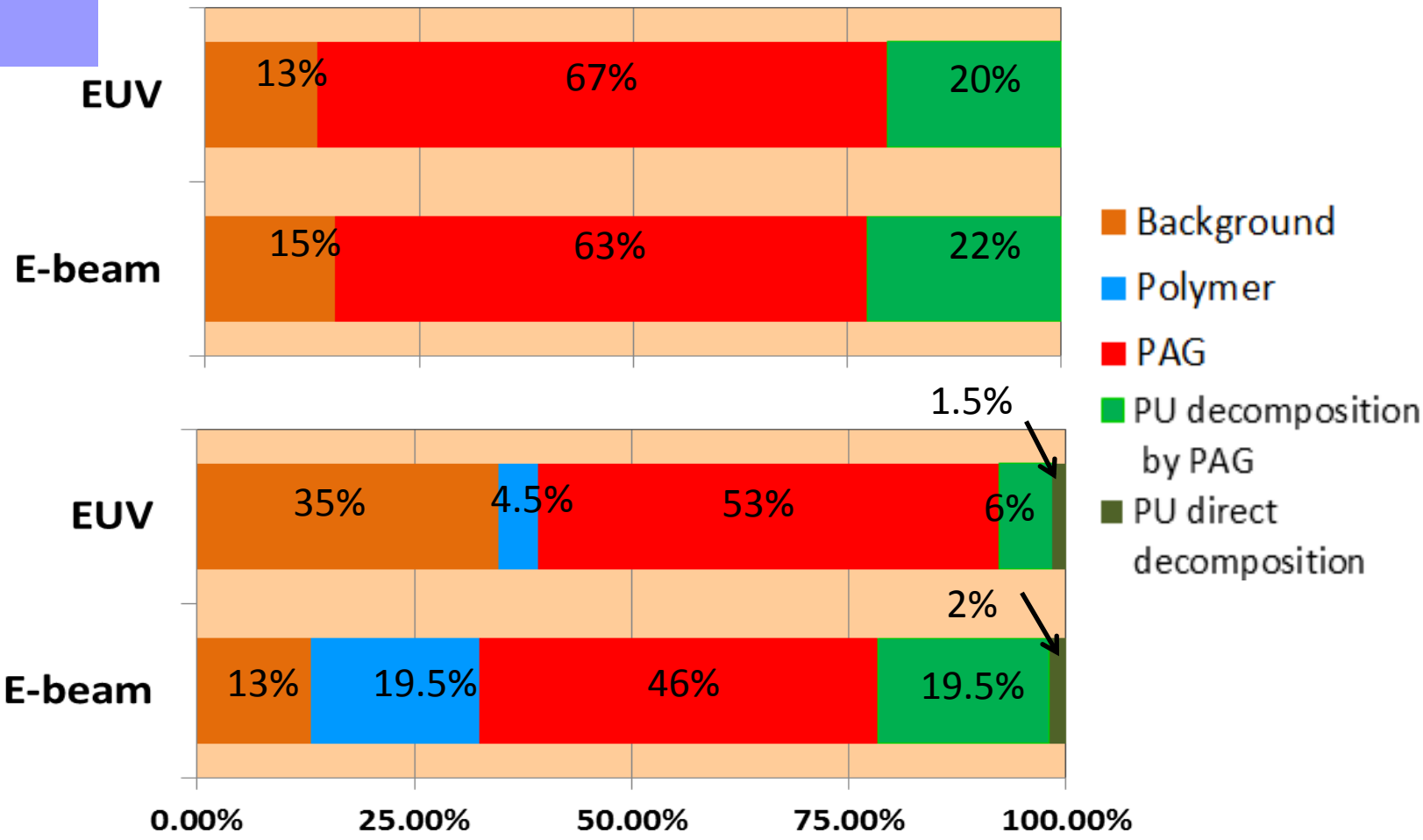


■ **PU peaks are disappeared in both of EUV and E-beam exposure.**

＃Normalized at the peak of amu78
＃BG are subtracted

Summary3: Composition of Outgassing and Contamination Thickness by EUV and EB

Contamination Thickness



Total Outgassin

The PAG and PU contribution in Contamination thickness are same in EUV and E-beam. But the composition of total outgassing amount shows difference.

Summary

■ Using the samples with different combination of resist components, the contribution of each components in the contamination thickness were investigated.

PAG contribution was 60～70%，and
PU　contribution was ～20%
in both of EUV exposure and E-beam exposure.

■ Most of the characteristic RGA peaks of PAG and PU were same in EUV and E-beam exposure.
But the peak ratio and total gas amount showed a little discrepancy.
We will study further on this finding.

Acknowledgment

This work was supported by New Energy and Industrial Technology Development Organization (NEDO).


END